

SMITH (J. M.)

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Public Hygiene -

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I.

REPORT OF THE COMMITTEE ON PUBLIC HYGIENE.

THE Committee on Public Hygiene, in submitting their report, beg leave, in the first place, to express their regret that the delay in publishing the Transactions of the Association of the last year should have occasioned any impediment to the performance of the duty assigned them. The effect of the delay referred to was to deprive the committee of the opportunity of acquainting themselves, in due season, with the subjects which had engaged the attention of their predecessors. Being ignorant, for the most part, of the details of the report of the last committee on hygiene, there would have been, had the present committee entered on their labours anterior to the publication of that report, no security against the reiteration of matters already brought before the Association. The desire of avoiding a fault of this kind, and especially of discussing questions to which the attention of the Association has not heretofore been invited, will, it is hoped, be admitted as an acceptable plea, if not a satisfactory apology, for the want of variety, and limited extent of research in the present report.

In the second place, the committee would observe that the subject of hygiene is so fertile of matters demanding for their elucidation experimental research and scientific generalization, that nothing short of a plan of investigation, well digested and carefully pursued, can yield results remunerative of the labour expended in obtaining them. A committee consisting of members widely separated from one another by distance, and prevented from entering on their work at an early period after their appointment, can scarcely be expected, by any conventional action, to select from the wide domain of hygiene suitable fields of inquiry, and to proceed methodically and advantageously in exploring them. With these impressions, the chairman of the present committee deemed it proper, in communicating with his associates, in February last, to invite them to prepare monographs on such hygienic subjects as they might severally make choice of,

avoiding those, however, which had been so fully and ably discussed by their predecessors. In thus adverting to the sources of their embarrassment in preparing their report, the committee deem it as not transcending their duty to suggest to the Association the propriety hereafter of assigning to the standing committee on hygiene special subjects of inquiry.

As a branch of medical science, hygiene is illimitable in the variety of its details. Its object is to discover and apply the means by which the vital powers may be so developed, regulated, and protected as to produce the greatest amount of ease, activity, and harmony of the organic and animal functions, its highest aim being to extend life without disorder to the period of its natural termination, or, in the language of Blumenbach, "to the ultimate line of physiology—to death without disease." Its scientific relations are to a great extent essentially etiological. To avoid disease it is necessary to know the disturbing causes of health. The influences which affect the vital properties are twofold. 1st. Those which, while rightly used are necessary to health, may become sources of disease. To this division belong what are denominated the *non-naturals*. 2d. Those which are never salutary, and the action of which is antagonistic to the normal vital forces. Among these are the qualities of the air which cause epidemic and some other forms of disease. From the modes in which these various morbid agents produce their effects on the human economy are deduced the principles of hygiene. As thus surveyed, it is obvious that hygiene comprehends the elements of etiology, and that, as a science, the former can never be in advance of the latter.

In regard to the general sources of disease, it is well known that some of them admit of correction by measures instituted by municipal authority, whilst others are beyond the control of legislative enactments. Of the former kind, are the emanations from filthy streets, sewers, marshes, human excretions in over-crowded habitations, and various common nuisances; and of the latter, the widespread influences which induce certain forms of epidemic disease. Against the assaults of these distempers, the utmost that can be done by Boards of Health is to point out their exciting causes and the means of avoiding them.

Whilst the civil, military, and naval relations of the laws or doctrines of health have long engaged the attention of governments, there is one aspect of the subject which has never been recognized as being of sufficient extent and importance to entitle it to the con-

sideration of a separate department of study. We refer to *hygiene in relation to epidemics*. In researches strictly confined to this subject, the varieties of epidemic distempers, and their causes, characters, and laws, would be investigated and generalized; and the means, general and special, of avoiding their attacks, and preventing their recurrence, shown in a distinct and systematic order. A manual exhibiting the present state of our knowledge of these topics, so arranged in its plan that everything peculiar to particular epidemics should be brought together, and consequently made readily accessible, would be an invaluable boon to society.

As the theme of his contribution to the present report, the chairman of the committee has selected the sources of typhus fever and the means suited to their extinction. His design is to show that the disease originates from human excretions; and to investigate the kinds and quantities of these matters concerned in its production. The inquiry is divided into two parts; the first relating to the origin of typhus from the excretions of persons in health, and the second to its origin from the excretions of persons in disease.

I. The human body in health is continually undergoing the processes of composition and decomposition. The materials which enter the system for its formation, after serving that purpose for a brief period, yield their places to other matters of the same kind, and their elements entering into new combinations, are ejected as noxious to the organism. In health, except in the growing state, the supply of the nutritive and the waste of organic excretive matters are in equilibrium; and as the principles received into the body for its formation acquire the property of life, so those resulting from the metamorphosis of the tissues and eliminated as excretions, lose that property. The excretions, therefore, are dead matter; and hence being subject to the influence of chemical laws, their elements enter into new arrangements, forming various new compounds, among which there is reason to believe is *idio-miasma* or the typhus poison.

To enable the political hygienist to obtain a scientific and practical view of the extent to which the excretions of the human body may, under favourable conditions, become the source of a febrile miasm, it is necessary to estimate the quantity of effete matter expelled from the system in a given time.

Sanctorius, who for thirty years weighed daily his own body, and also his food and drink, and solid and liquid discharges, found when eight pounds of ingesta were taken, that his body returned

every twenty-four hours to the same weight, and that he lost 3 pounds by urine and fæces, and 5 by transpiration. Keill makes the daily average of the fæces 5 ounces; the urine 38 ounces, and the perspiration 31 ounces, the ingesta being 75 ounces. Hartman found when the ingesta were 80 ounces, the fæces were 6 or 7 ounces, the urine 28, and perspiration 45 or 46 ounces. In Von Gorter's experiment, when the ingesta were 91 ounces, the fæces amounted to 8 ounces, the urine to 36, and the perspiration to 49 ounces. Sauvage ascertained that when the ingesta were 60 ounces, the fæces were 5 ounces, the urine 22, and the perspiration 33 ounces.* The researches of Robinson,† and Lining‡ furnish similar estimates. An exact accordance between the results obtained by different experimentalists can scarcely be expected, seeing that so many influences, such as age, temperament, condition of the atmosphere, and state of health, are continually operating to vary the quantities of the different excretions.

In estimating the amount of transpiratory matter, the above-mentioned inquirers make no distinction between the cutaneous and pulmonary exhalations. The first successful attempt to separate these excretions, and determine their relative and absolute quantities, was made by Lavoisier and Seguin. These gentlemen found from all their experiments that "the loss of weight caused by the insensible transpiration is 18 grains per minute, and that of these 18 grains 11 on the average belong to the cutaneous transpiration, and 7 to the pulmonary. Agreeably to this estimate, the quantity of matter lost through the lungs and skin in 24 hours is 54 ounces (troy). In the above estimates no notice is taken of the quantity of oxygen received into and discharged from the body by the lungs and skin.

From these statements it appears that the amount of cutaneous and pulmonary excretion exceeds the aggregate sum of the urine and fæces, being sometimes, according to Sanctorius, in the ratio of five to three.

In respect to the different excretions, it is observable that two of them, to wit, the urine and fæces, are occasionally or periodically discharged, under the direction of the will, and that the disposition usually made of them seldom admits of their becoming a source of disease. It is otherwise with the materials exhaled from the lungs and skin. These matters are constantly escaping from the organs

* See Dunglison's Physiology.

† See a Treatise of the Animal Economy, by Bryan Robinson, Dublin, 1732.

‡ See Transactions of the Royal Society of London, 1743.

which secrete them; and while the more viscid portions of them adhere to the skin and clothing of the individual, the more volatile parts assume the form of vapour, and are widely dispersed in the open atmosphere; or remain, in circumstances of confinement, suspended in the air or attached to surrounding objects.

Now, it is well known that when the effete matters evolved from the lungs and skin are accumulated and long retained in a confined place, they become highly offensive and noxious to those who are exposed to them. We are not aware that any attempt has been made to illustrate this subject, by calculating the quantities of waste matters thrown off from the cutaneous and pulmonary surfaces of individuals, isolated or congregated, during lengthened periods of time. As such calculations may aid us in forming a right apprehension of the extent of the agency of human excretions in producing disease, in dense populations, we shall endeavour to supply them. There is reason to believe that inquiries pursued in this direction will exhibit more clearly and extensively than has hitherto been done the true grounds on which, in relation to the origin and diffusion of typhus fever, a system of hygiene should mainly rest.

The lowest quantity of transpiratory matter in 24 hours, among the estimates above cited, is that quoted from Keill, namely 31 oz.; and the highest that furnished by Lavoisier and Seguin, 54 oz. The average of them all is 45 oz. Carpenter says, "The maximum loss by exhalation, cutaneous and pulmonary, in 24 hours, is 5 lbs.; the minimum, $1\frac{3}{4}$ lbs." Now we shall probably not vary far from the truth, if we assume 40 oz. as the general average.

But before entering into the proposed calculations, it is essential, to a full analysis of the subject, that we inquire what are the proximate principles which constitute the cutaneous and pulmonary excretions? The elements of the typhus poison are undoubtedly present in the excretions in question, and hence an answer to this inquiry may lead to the disclosure of the principles which pollute the atmosphere of close and crowded habitations, and which are chiefly concerned in generating that poison.

Thenard, in his analysis of the matter of perspiration, found it to consist of a large proportion of water, some saline and acid bodies, oxide of iron, and a small amount of *animal matter*. According to the analysis of Berzelius, the proximate principles are water, muriates of potassa and soda, lactic acid, and lactate of soda, and a little *animal matter*. These results are probably near approximations to truth: they accord substantially with those afforded by the quali-

tative analysis of Anselimo and Simon. It is to be noticed, also, that with the matters exhaled from the skin, are, according to Collard de Martigny, variable quantities of nitrogen and carbonic acid gas.

Of the proximate principles present in the pulmonary and cutaneous excretions, there is probably no one of them so directly concerned in generating *idio-miasma*, or the typhus poison, as the *animal matter*; and hence, it may be interesting to estimate the quantity of that material separately from the entire amount of matters discharged from the lungs and skin, in a given time. Happily this, we are enabled to do, by inferences deduced from the investigations of Mr. Ancell, of London.* Adopting the chemical views of Liebig, and pursuing his method of research, this gentleman has ingeniously attempted "to exhibit the various modes in which the equivalents of the component parts of the *ingesta* are eliminated from the body, and to ascertain the elementary constitution of the solid, fluid, and gaseous compounds into which they are distributed in the *egesta*." The subject of Mr. Ancell's experiment was a healthy man, who, in twenty-four hours, took as *ingesta* 96 oz., and received, by estimate, into the system by the lungs, stomach, and skin, 32 oz. 23 dwt. 4 grs. of oxygen, making a total of matter received into the body of 129 oz. 3 dwt. 4 grs. The weight of the individual was the same at the end as at the beginning of the experiment. The *egesta* during the time was found to be *fæces* 5 oz. 10 dwt.; urine, 42 oz. and matters eliminated from the lungs and skin, consisting of water, carbonic acid, sweat, tears, animal matter, &c., 81 oz. 13 dwt. 4 grs., in all, making a quantity equal in weight to the matters introduced into the system.

The great difference in the amount of the excretions by the lungs and skin, in Mr. Ancell's estimate, and the quantities stated by former experimentalists arises from his bringing into his calculation the amount of oxygen taken into the system through the lungs, stomach, and skin, and expelled from the pulmonary and cutaneous surfaces in combination with carbon and hydrogen, forming carbonic acid and water. Subtract the oxygen in question, and the quantity of matters excreted by the lungs and skin is reduced to 48 oz. 14 dwt., a sum differing but little from the estimates given, as before noticed, by Hartman and Von Gorter.

On carefully analyzing the table in which the results of Mr. An-

* See London Lancet, Feb. 4th, 1843.

cell's inquiries are exhibited, it is found that of the 81 oz. 13 dwt. 4 grs. of cutaneous and pulmonary excretions, 42 oz. 13 dwt. 10 grs. consist of water, 9 dwt. of dry materials, and 38 oz. 10 dwt. 18 grs. of gaseous matters. The 9 dwt. of dry materials are found in the secretions of the skin, and consist of *animal matter* 8 dwt., and salts 1 dwt., which added to the *animal matter* exhaled with the pulmonary vapour, give, exclusive of the salts, 11 dwt. 7 grs.: that is, the amount of *animal matter* emitted with the excrementitious discharges through the lungs and skin in twenty-four hours. This amount probably exceeds the usual quantity, and consequently, to avoid exaggeration, we shall assume 10 dwt. as the normal daily average.

Having thus ascertained, in a mode as inductive as the extent of our knowledge admits, that the quantity of pulmonary and cutaneous excretions is 40 oz. daily, and that, of this amount 10 dwt. consist of organic or animal matter, we are prepared to calculate the quantities of such excretions furnished in given times by one or any number of persons confined, or crowded in private dwellings, jails, and ships, or congregated in armies and cities; and to this task we shall now apply ourselves.

1st. The excretions of a single individual in health are seldom productive of typhus fever. The disease, however, may arise from that source, especially when there happens an extraordinary combination of circumstances favourable to the generation of *idio-miasma*; as was the case in the instance related by Dr. Harty, of a woman confined by her husband for weeks in a small, dark closet, without light or air, and without a change of clothes. The two gentlemen who liberated her were overpowered while engaged in doing so by the effluvia of the place. At the end of a week both sickened with fever; one died and the other recovered with difficulty.* In examining these interesting facts, let us suppose that the weeks of the woman's imprisonment were equal to thirty-five days, though the period may have been much longer. Now the entire quantity of matters thrown off by the lungs and skin of the woman, at the rate of 40 oz. daily, in that time, is 116 lbs. 8 oz., and of the animal matter, at the rate of 10 dwt. daily, is 1 lb. 5 oz. 10 dwt. Here, then, to say nothing of the vitiation of the air by carbonic acid gas, a febrific effluvium was generated, doubtless, from the effete and excreted animal matter.

* See an Exposition of the Nature, Treatment, and Prevention of Continued Fever, by H. McCormac, M. D., London, 1835.

If it be questioned, however, whether the quantity of animal matter emitted from the lungs and skin, in the time mentioned, was not sufficient to produce so concentrated and active a poison, as manifestly existed in the place, it may be supposed that the emanations from the fæces and urine which, probably, were not regularly, if at all removed from the apartment, contributed to its production. It is remarkable that the woman herself continued in health, a circumstance attributable to her system having been gradually inured to the impression of the miasm from the time of its incipient production.

2d. Among the more common sources of typhus fever are the effete matters of the human body, accumulated and long retained in private dwellings. The facility and promptness with which such accumulations take place in the close and crowded hovels of the poor may be readily explained by calculating the amount of materials excreted from the lungs and skin of a definite number of individuals living in the same habitation. Let us suppose a family, one, of which there are hundreds of examples, consisting of ten adult persons, dwelling in a small, ill-ventilated house, and negligent of personal and domestic cleanliness; and, further, that the time severally passed within doors by the ten individuals, some of whom are constantly at home, while others are temporarily absent, amount in the aggregate to twelve hours out of every twenty-four. The mass of effete matters thrown out by the lungs and skin, by such a family within their dwelling, in one month, is 500 lbs., in six months, 3033 lbs. 4 oz., and in one year 6083 lbs. 4 oz.* Though by far the greater part of these excretions consist of carbonic acid, water and salts, yet the quantity of ejected animal matter is not inconsiderable. It amounts in one month to 6 lb. 3 oz.; in six months to 37 lb. 11 oz.; and in one year to 76 lbs. 0 oz. 10 dwt. In such circumstances it is, and especially in seasons in which the prevalence of typhus is favoured by an epidemic influence, that the disease often spontaneously originates in the squalid homes of the poor.

If we extend this mode of investigation to a number of families, each consisting of ten members, residing in contiguous tenements, we shall obtain results which may forcibly impress the mind of the public hygienist. Instead of a hypothetical example, let us select one which is reported as actually existing. "In one of the *cul-de-*

* In these and the subsequent calculations a month is reckoned as 30 days; six months as 182 days; and one year as 365 days.

sacs in the town of Leeds, there are thirty-four houses (described as impure and ill-ventilated), and in ordinary times there dwell in these houses 340 persons, or ten to every house; but as these houses are many of them receiving-houses for itinerant labourers, during the period of haytime and harvests and the fairs, at least twice that number are then here congregated." It is probable that of the 340 persons who ordinarily occupy the thirty-four houses some are children; yet, though this may be true, the occasional itinerant lodgers doubtless make the number residing in each house throughout the year equivalent to ten adult persons. Now, if the cutaneous and pulmonary excretions of one adult be 40 oz. daily, then the 340 adults discharge by the lungs and skin, within their dwellings, in the half of one day or twelve hours (assuming this to be the average of the time passed severally by the whole number in their houses), 566 lbs. 8 oz., and in the same proportions, in one month 17,000 lbs.; in six months, 103,133 lbs. 4 oz.; and in one year, 206,833 lbs. 4 oz. It is said that there were removed from the place in which the houses in question are situated, during the days of the cholera, 75 cart loads of manure—a quantity, allowing each cart load to weigh 1200 lbs., not equal to half the amount of the materials eliminated from the lungs and skin of the 340 persons, within the thirty-four houses, in one year. If we now calculate the amount of animal matter cast out from the 340 persons, it will be found, at the daily rate of 10 dwt. for each person, in the half of one day, to be 7 lbs. 1 oz., and, in corresponding proportions for each day, in one month, 212 lbs. 6 oz.; in six months, 1289 lbs. 2 oz.; and in one year 2585 lbs. 5 oz.: this last amount being more than two cart loads, each of the weight above mentioned.

We would here, for a moment, arrest our inquiry, in order to remark, what, indeed, is so well known that it needs scarcely to be stated, that the entire amount of effete materials evolved from the lungs and skin of persons living together, is not retained within their dwellings. In every human habitation there are openings or passages which admit of more or less ventilation, or, in other words, through which there is constantly a more or less free interchange of the air within with the air without. Now of the various proximate principles present in the cutaneous and pulmonary excretions, viz., carbonic acid gas, water, salts, and animal matter, the first, agreeably to the law of the diffusion of gases, rapidly escapes through the apertures mentioned, and is widely dispersed in the general atmosphere; and by virtue of the same law, the water, assuming the form

of vapour, and holding the salts in solution, and suspending a fraction of the organic matter, also readily finds its way into the open air. But with the residue of the animal matter it is otherwise. The organized atoms, exhaled from the human body, have not, according to Professor Graham, "the diffusive force inherent in gases and vapours;" and consequently are slow in dispersing themselves. In confined habitations, where there is no perfilation, they long remain floating in the air, or become attached to the persons, clothing, bedding, and furniture of the inmates. It is owing, therefore, to the difference between the diffusive property of the molecules of *animal matter*, and that of the *carbonic acid gas*, exhaled from the skin and lungs, that the former is, in ordinary, much more liable, though vastly less in quantity than the latter, to impart to the air of human dwellings a morbid quality.

3. Pursuing the same method of investigation, we may next estimate the amount of material excreted from the lungs and skin of persons confined in jails. The history of prisons abounds with examples of the origin of typhus from human filth accumulated in them. "The most pernicious infection, *next the plague*," says Lord Bacon, "is the smell of the jail, where prisoners have been long, and close, and nastily kept." There are few things which more strikingly illustrate the later advances in civilization than the improvements in the hygienic condition and discipline of prisons. Indeed, so great have been the reforms in the sanitary police of these institutions, since the time of Howard, that jail fever is now comparatively of rare occurrence. The disease, however, is still occasionally induced from excessive over-crowding. Take, for example, the prison at Rheims, which, it is said, is calculated to receive one hundred prisoners, that is, to accommodate this number without endangering their health. In general, it contains from 130 to 150. But, as M. Landouzy informs us, in 1839, the number rose to 180 and 190; and that fever broke out in the most crowded apartments.* It is evident, therefore, that if the prison is fitted to receive but 100 persons, any addition to this number must render its inmates liable to generate the cause of fever. According to the daily average of 40 oz. from one individual, the amount of cutaneous and pulmonary excretions from 100 persons in one month is 10,000 lbs., in six months, 60,666 lbs. 8 oz., and in one year 121,666 lbs. 8 oz. The quantity of animal matter exhaled in one month is 125 lbs., in six months 750

* See Archives Générales de Médecine, Janvier, 1842.

lbs. 4 oz., and in one year 1520 lbs. 10 oz. Now it appears that in the prison at Rheims ample provision is made to prevent the occurrence of disease from the transpiratory matters of 100 prisoners. But how different was it when the number of prisoners was nearly doubled; and when, of course, the quantity of effete matters thrown out from the lungs and skin was proportionally augmented? Then it was that the mass of excretions, over and above the amount which the space and means of ventilation are sufficient to render innocuous, became the source of a miasmatic poison; and then it was that typhus broke out.

4. In like manner may be determined the quantity of pulmonary and cutaneous excretions of passengers in ships, sailing on long voyages. No human habitation is so liable to suffer from disease, by overcrowding, as a vessel that navigates the ocean. The annals of jail fever afford no examples of the mortality of that disease more appalling than those of the ravages of ship fever within the last few years. Of the emigrants, near 100,000, who left the British Isles for Canada, in 1847, over 5000 perished on the passage; and the deaths in the passenger ships bound to the United States, in the same year, were scarcely less numerous. From some ships upwards of 100 were buried at sea. Nor can this immense mortality be surprising when we contemplate the hygienic condition of the ships at the time of their arrival. A writer, in a Boston paper, who accompanied the port physician of Boston to a sickly emigrant ship, in describing the scene that the steerage of the ship presented, says: "As we descended by the light of a lantern between decks, and inhaled the fever-generating air, the concentration of 150 foul and infectious breaths, and beheld the ghastly victims of want and disease, and the filth in which they were literally imbedded, we could think of nothing but the black hole, or the middle passage." The condition of this ship affords a fair specimen of that of almost every vessel in which fever extensively appeared, while crossing the Atlantic, in 1847. The causes to which the occurrence of typhus in passenger ships are chiefly due, are not always under human control. The time occupied by ships in crossing the ocean varies greatly in length; and the health and good condition of the passengers mainly depend upon the opportunities they enjoy for spending a portion of each day in the open air, and on the cleanliness of their person, and the purity and aeration of the steerage. Whilst fine weather allows them to visit the deck, tempest and other atmospheric inclemencies compel them to keep below.

Now the quantity of matters eliminated from the lungs and skin in the steerage varies of course with the number of passengers, the length of the voyage, and the number of hours passed in the steerage. If 300 adult passengers spend twelve hours daily between decks, the matter there emitted from the lungs and skin during a voyage of thirty days will amount to 15,000 lbs.; and in the course of a voyage extended to forty-five days, to 22,500 lbs. The quantity of animal matter, calculated, as in former examples, will amount in thirty days to 187 lbs. 6 oz., and in forty-five days to 281 lbs. 3 oz. The construction and interior arrangements of the vessels, usually employed in transporting emigrants, are peculiarly unfavourable to the rapid diffusion of these large amounts of excrementitious transpirations. The main and direct openings into the steerage are generally too contracted to admit of free ventilation; and are occasionally from necessity closed; offensive accumulations consequently take place; the retained carbonic acid renders the air unfit for respiration, and the atoms of animal matter, having but little or no diffusive force, transform themselves into a pestiferous miasm.

Now, is it conceivable, in the true spirit of philosophy, that when there is such an amount of human exhalations, more or less of which is retained, in the circumstances mentioned, it is necessary to resort to the hypothesis of a specific contagion to account for the ravages of fever among those who lodge in the midst of them? When typhus appears in a foul and crowded emigrant or transport ship, the inference naturally deducible from a common sense view of the case is, that the disease originates from a poison generated from the detrita of the passengers, and especially from those emitted from the lungs and skin, to which, in many instances, are added the emanations from the fecal and urinary discharges and the matters ejected from the stomach in cases of sea sickness. The theory that typhus is produced exclusively by a specific contagion, analogous to that of small-pox, introduced on board at the port of departure is invalidated, if not overthrown, by the fact that the disease never prevails among the passengers of a ship, unless the condition arising from filth and deficient ventilation, already described, exists. If typhus be produced by a specific contagion, the disease would prevail in clean as well as in foul ships, a circumstance which never happens; and, besides, if the fever depends upon contagion, it would most probably show itself among the passengers within a few days after their embarkation, whereas the truth is, typhus rarely occurs in a ship until she has been several weeks at sea, and the steerage has become polluted with vitiated human effluvia.

5. In further attempting to illustrate the extent to which human exhalations sometimes become the source of an active fever poison, let us estimate the quantity of the pulmonary and cutaneous excretions of a definite multitude of persons, congregated in circumstances different from those above mentioned; for example, a large body of troops.

The condition of a common soldier, in respect to personal cleanliness, is extremely different in different circumstances. In times of peace, and while under a system of regular and rigid inspection of his person, apparel and quarters, there is usually nothing about him from which the typhus poison can originate. But it is otherwise when in active service in the field; he perspires freely, neglects ablution, and is long without a change of clothing. In such circumstances, whether in bivouac, or on the march, his garments become excessively filthy, and his person besmeared with the excrements of the skin. In such a condition, according to Foderé, were the French troops on their return from Italy in 1799; their clothes were in rags, their shirts glued to their bodies for several months, and their skin covered with filth. Such impurities long attached to a soldier, render him an object scarcely less dangerous to approach in a friendly interview than to meet in a hostile rencontre. "The same matter," says an American writer, "which renders shirts, drawers and stockings *disagreeable* to the wearer after two or three days will render them pestilential after five or six weeks close and incessant application to the skin."*

In order to form some idea of the magnitude of this source of disease in armies, let us compute the quantity of waste material discharged from the lungs and skin by a given number of troops, say 20,000, in definite periods of time. Basing the estimate on the daily average of 40 oz. from one individual, it appears that a corps of that number, eliminate in one day, 66,666 lbs. 8 oz.; in one month, 2,000,000 lbs.; in six months, 12,133,333 lbs. 4 oz.; and in one year, 24,333,333 lbs. 4 oz. But, as by far the greater part of this amount of effete matter consists of water, carbonic acid and salts, which probably take no part in the generation of the typhus miasm, it is necessary, to a just view of the subject, to estimate the quantity of animal matter evolved from the cutaneous and pulmonary organs. If 10 dwt. be the daily quantity from one individual, then 20,000 men emit in one day 833 lbs. 4 oz.; in one month, 25,000

* New York Med. Repository, vol. v. p. 70.

lbs.; in six months, 151,666 lbs. 8 oz.; and in one year, 304, 166 lbs. 8 oz.

It will be observed that the above estimates comprise the exhalations from both the lungs and skin. Now, it is obvious that so long as troops are serving in a campaign, or moving in the open air, the pulmonary excretions are wholly innocuous, being dispersed in the atmosphere, whilst those of the skin, or, rather a part of them attaching themselves to the body and clothing, furnish the elements from which are generated the *materies morbi* of typhus. It is only when troops are in barracks or in close tents that the pulmonary exhalations unite with the cutaneous, in producing a fever poison.

The quantity of sordid material adhering to a soldier in the circumstances now described, it is not easy, nor is it important, to determine. The rank odor, proceeding from his person, manifests, what in truth is apparent to the eye, that the quantity is not inconsiderable; and, at the same time, evinces that the substance in question has undergone a chemical transformation.* It is also to be noticed, that, though freely exposed to the air, the mass of filth on his person and raiment suffers no diminution by evaporation, the loss, sustained in this way, being constantly replaced, with additions, by the incessant discharges from the skin. A soldier in this condition may not inaptly be said to be clothed in a suit of fomites; and an army composed of such men, and moving in a body, may be likened to a morass, the emanations from which produce fever in those who come within the circle of their influence. It was in this manner, we are told, that the ragged and filthy French troops, above alluded to, disseminated the germs of typhus fever in the towns and villages that lay along their route from Italy; and it is remarkable that it was not until after halting at places beyond the reach of pursuit, and being concentrated in confined situations, they themselves succumbed to the influence of the noxious effluvia emanating from their own persons. There is reason to believe that a very large proportion of the ravages of fever, which have occurred at different epidemic

* Winterbottom, in discoursing on the odor emitted from the human body, cites the following curious remarks from a prize essay by Ritter. "The want of ablution occasions that insupportable and specific smell which the soldier, when in mass, spreads around him, and which differs in different nations. The smell of Hungarians, and Croats, differs from that of German soldiers; and an English regiment smells extremely different from a Spanish, Bohemian or Dutch one. The specific smell of different classes of men may be attributed to their mode of life and employment, as well as to their domestic and national customs."—*Thoughts on Contagion. Monthly Journal of Foreign Medicine*, vol. iii. Philadelphia, 1829, from the *Edinburgh Medical and Surgical Journal*.

periods, in the armies of Europe, was caused by *idio-miasma*, generated, under a favoring epidemic influence, from the personal filth of soldiers, and by the union of this poison with common malaria, forming the compound poison *idio-koino-miasma*. Dr. Rush, in speaking of the fever produced by "*excreted matters*," says that "it has been but little known in the United States since the Revolutionary war, at which time it prevailed with great mortality in the hospitals and camps of the American army."*

6. If any interest have been awakened by the results afforded by the mode here adopted of studying the etiology of typhus fever, it will not, perhaps, be lessened by proceeding to estimate the quantity of matters transpired from the skin and lungs of a city population, in various periods of time.

The inhabitants of a densely populated town may be regarded as a single family, living in contiguous or narrowly separated apartments, any number or the whole of which may as certainly be rendered infectious by over-crowding as the cells of a prison. In no mode perhaps can the danger from this source of disease be so distinctly impressed on the mind as by estimating the quantity of waste matters eliminated from the bodies of the people of a city in given times. If we assume as a numeral basis a population equal to 200,000 adults, it will be found, if calculated as in former examples, that the entire pulmonary and cutaneous egesta amount in one month to 20,000,000 lbs. in six months to 121,333,333 lbs. 4 oz; and in one year to 243,333,333 lbs. 4 oz.; and that the exhaled animal matter alone amounts in the first of these periods to 250,000 lbs., in the second to 1,516,666 lbs. 8oz., and in the third to 3,041,666 lbs. 8oz.

The health of a city depends, in no small degree, upon the distribution of the inhabitants over an area of sufficient extent to admit of the free ventilation of every dwelling. When such a distribution obtains, and attention is given to personal and domestic cleanliness, a population of 200,000, or any greater number, will be as secure against the invasion of typhus as are the inmates of a commodious, cleanly and well-aired private dwelling. But populate a town as densely as are the alleys and courts of many cities, and the consequence will be that the whole population will feel the influence of an *idio-miasmatic* atmosphere, and disease be co-extensively produced. Though such instances are extremely rare, yet history furnishes us with a notable example. We allude to the plague at Athens, which,

* New York Med. Repository, vol. vi. p. 155.

occurred in the time of Pericles, and the terrors of which are so thrillingly sketched by Thucydides. We are told that the people of Attica, during their warfare with the Peloponnesians and their confederates, took refuge within the walls of Athens; and that so great was the multitude assembled in the city, that every spot was excessively crowded. The ordinary population of Athens, at the time in question, cannot be satisfactorily determined. Xenophon reports that there were 10,000 houses; and a modern writer, founding his calculation on this statement, and assuming 12 inmates to each house, makes the number 120,000. Dr. E. H. Smith, in his admirable essay on the Athenian pestilence, states that the ordinary number of citizens was about 50,000, and that it was increased by the new comers from the country to more than 400,000. The plague broke out in the spring of 430, A. C. one year after the commencement of the removal from the country, and extended into the following summer. In its greater severity, it prevailed probably at least six months, and its ravages were renewed in several subsequent years.

With these data, we may compute the quantity of effete matter eliminated by the lungs and skin of the people in the space of six months. Supposing the usual population, taking the average of the above hypothetical estimates, to have been 85,000, and these to be equivalent to 50,000 adults, then, if each furnished daily 40 oz., the total quantity in six months amounts to 30,333,333 lb. 4 oz., of which the portion of animal matter, at the rate 10 dwt. daily, amounts to 379,166 lb. 8 oz. If we now assume that, to the stated population, there were added 350,000 fugitives from the country, making a total of 435,000, and that this number, including all ages, was equal to 300,000 adults, it will be found that the material excreted by transpiration was in six months 182,600,000, and that of this 2,275,000 lb. consisted of animal matter. And, lastly, if we subtract the quantity of exhaled excretions furnished by the ordinary population of Athens from that evolved by the augmented multitude, there will remain of the total exhalations 151,666,666 lb. 8 oz.; and of the animal matter 1,895,833 lb. 4 oz. These latter numbers, then, express the amount of exhaled matter, over and above the quantity emanating from the stated population of the city, in the course of the six months in which the plague raged with the greatest violence; and though there is good reason to believe that other causes, such as the miasm from accumulated fæces, and masses of decaying organic substances strewed on the earth, exerted a powerful agency, under the influence

of a peculiar epidemic meteoration, in causing the distemper, yet there can be no hesitation in ascribing to the *idio-miasma*, produced from the immense volume of molecules of exhaled animal matter, suspended in the air, the effect of exasperating its malignity, and swelling its mortality. Thucydides says that "the general removal from the country into the city was a heavy grievance, more particularly to those who had been necessitated to come hither; for as they had no houses, but dwelt all the summer season in booths, where there was scarce room to breathe, the pestilence destroyed with the utmost disorder, so that they lay together in heaps, the dying upon the dead, and the dead upon the dying." Plutarch tells us that the Athenians raved against Pericles for causing the plague, and attempted his ruin, "being persuaded by his enemies that the sickness was occasioned by the multitude of out-dwellers flocking into the city, and huddled together in the height of summer, in small huts and close cabins, where they were forced to live a lazy inactive life, instead of breathing the pure and open air to which they had been accustomed. Of all this (they affirmed) he was the cause, who at the commencement of the war admitted within the walls such crowds of people from the country, and yet found no employment for them; but let them continue pent up like cattle to infect and destroy each other without affording them the least relief or refreshment." That such an epidemic should have sprung mainly, if not exclusively, from human exhalations cannot be doubtful or surprising, especially when the amount of these are rightly estimated, and their proclivity to generate a pestilential miasma is recognized. The sentiments of De Pauw, in relation to the Athenian plague, fully accord with the view here taken of the etiology of the disease. "To seek," he says "in Ethiopia the origin of the disorder, so evidently arising from a multitude of men heaped and pressed together, would be absurd, especially as its influence did not extend beyond the walls of Athens, and was totally unknown in every other part of Greece. Similar effects would be now produced in any town where the particles of the atmosphere are entirely changed by being charged with different noxious effluvia, as frequently happens in fleets or among armies encamped in too close order."

II. Having in the foregoing inquiries confined our attention to the excrementitious exhalations of persons in health, as the primary and chief source of the typhus poison, we now propose to examine the relations of that poison to the excretions of persons in disease, and especially of those affected with typhus.

Many distinguished pathologists regard typhus as springing exclusively from a specific *contagion*. That the disorder is communicable, under certain circumstances, there is no question. The communication, however, is effected by the transmission of a principle which, in its nature and mode of origin, has no analogy with the poisons of small-pox, measles, and scarlet fever. The poisons of these diseases are the products of specific morbid secretions, or vital processes which are respectively *sui generis*, whilst the poison of typhus consists of the ordinary excreted matters chemically altered in their properties. As, then, the excrementitious emanations from a typhus patient may be transmitted to a person in health, and in him produce typhus, the disease of course may be said to be communicable. But as the poisonous material communicated is totally unlike a specific contagious virus, the disease in question cannot with propriety be considered *contagious*. The disorder is strictly the effect of a chemical aeriform poison, and as this originates from human excretions, the poison is correctly denominated *idio-miasma*.

The excretions of patients affected with any form of disease may produce typhus fever; only, however, when they are accumulated and long pent up in confined apartments, or when they are highly vitiated or putrescent, at the moment of their elimination from the body, which is generally their condition in the more malignant forms of typhus. But even when in this form they are rarely the cause of fever, if the persons, clothing, and bedding of patients be preserved clean, and pure air be freely admitted to their apartments.

From inquiries, instituted to determine from which of the special excretions of persons in disease *idio-miasma* mostly originates, it has been found that the cutaneous and pulmonary transpirations generally furnish the elements of the poison. It is true, these excretions are variable in quantity, especially in febrile disorders, being sometimes greatly diminished, and at other times excessive. At no time, however, are they entirely suppressed. Febrile heat, though usually attended with a decrease of exhalation, promotes evaporation, and hence in part the dryness of the skin. When not apparent to the eye or touch, the cutaneous emanations are often manifest to the sense of smell. Edwards, in his work on the Influence of Physical Agents on Life, expresses the opinion that the perspiration can never be entirely suppressed; and Dr. Southwood Smith, in speaking of the odour which belongs to a typhus fever patient, that "it is so characteristic, that a person familiar with the disease might in many cases be able to pronounce, merely from the odour of the effluvia that arises from the body, whether the disease were fever."

With respect to the urine and fæces of the sick, they are, as we have said of those of persons in health, discharged occasionally, and are commonly removed from the apartment immediately or shortly after they are voided; and hence they are in general comparatively innocuous. It is only, or, for the most part, when these evacuations occur involuntarily, or are allowed to remain in the room of the sick that they are sources of a fever poison.

It is then to the excrementitious matters thrown off from the lungs and skin of diseased persons that the poison of typhus is mostly traceable. Such matters, transformed into a febrific principle and diffused in the air, constitute what Dr. Miller denominates *atmosphæra idio-miasmatica*. Every patient affected with typhus in its graver form, in a close apartment, is surrounded by such an atmosphere, and it is by the attendants and others coming within the circle of its influence that the disease is propagated. When many typhus patients are assembled together in a close and narrow space, the miasmatic atmospheres of the sick gradually widen their circles of activity, until meeting and blending together the whole place becomes pestiferous. The liability of nurses and physicians of contracting fever in an infirmary, is generally proportionate to the number of typhus cases admitted into the wards. Dr. Christison says that, "it has been invariably remarked that the admission of a few cases into a general ward is attended with little or no risk of the fever passing to the other inmates of their wards. But so soon as the cases exceed considerably a third of the whole, then the fever begins to show itself among the domestic attendants, and to appear among the other patients." Similar observations have been made in the New York Hospital. It is remarked by an English writer, in reference to the admission of fever patients into general hospitals, that "it has been found safer and better to have them scattered as single cases through different wards instead of congregating them together into one;" and he adds that "this plan has been adopted in more than one of the London hospitals; and we believe that there has been, on the whole, no cause to regret having followed it."*

The fact is here deserving of special notice, that the matters eliminated from the lungs and skin of a *solitary typhus patient* in an ill-aired room, acquire a febrific property in a period of time much short of that in which a fever poison is generated from the combined

* Med.-Chirurg. Review, No. 105, p. 229.

excretions of several healthy individuals shut up in a close apartment. This is so for the reason that the exhalations in typhus are highly vitiated from the time the disease is sufficiently developed to be recognized, and, having a strong putrescent tendency as the disease advances in its downward course, are rapidly transformed into idio-miasma.

In regard to the quantity of excrementitious matters discharged from the body during the course of an ordinary attack of fever, we have no definite knowledge. Among the changes which take place in a typhus patient, there are few more striking than the emaciation. The weight of the body is sometimes greatly reduced. A part of the waste matters escape by the bladder and rectum; but the loss which the body sustains by discharges through these emunctories is, in a measure, replaced by the ingesta, and consequently a large portion of the transformed blood and tissues passes off by the lungs and skin.

It would be interesting to inquire what the average quantity is of the pulmonary and cutaneous excretions in cases of fever of a definite duration; and what proportion these bear to the alvine and urinary egesta. We have seen that an adult in health loses daily by the lungs and skin on an average 40 oz. Whether more or less than this quantity is lost by a patient ill with fever, we have not the means of determining. The amount probably does not, if at all, fall much below the quantity lost in health. In some cases, and especially in some conditions of fevers, there are copious sweats, which compensating for deficiency of perspiration in other cases and other conditions of the disease, bring up the total amount to the average quantity in health. In some febrile epidemics, the transpirations probably exceed the normal amount.

The excretions of a starving man exceed the half of those of one who is duly nourished. Currie mentions the case of an individual who was unable to swallow, and whose body lost 100 lbs. in weight during a month.* This is exactly the average amount transpired from the lungs and skin of a healthy man in 30 days, and it is probable that, in the case here referred to, the greater part of the matters eliminated escaped through these organs. Now the equilibrium between the waste and supply of the system, in an attack of fever, is broken up, the former exceeding the latter, and consequently emaciation follows. The difference of weight of the body at the

* Liebig's Animal Chemistry, p. 25.

accession and termination of the disease in a case of ordinary duration, cannot be less than 30 or 40 lbs. Though a diarrhœa and the alvine discharges produced by cathartic medicines may alter the relative normal proportions of the different excretions, yet there is reason to believe that a considerable if not the greater part of the transformed tissues, together with much of the drink and food introduced into the system during the disease, is eliminated from the lungs and skin. If the daily transpirations of a typhus fever patient be equal to 36 oz., that is 4 oz. less than the quantity in health, the amount in 20 days will be 60 lb., a quantity which, if there be any impediment to its diffusion, cannot fail to contaminate the air of a small apartment. It is from such transpirations retained in the narrow and close hovels of the poor that typhus is propagated, in seasons favourable to the epidemic prevalence of the disease.

But though private typhus patients may communicate the disease by their exhalations to their attendants and visitors, and thus spread the malady from house to house in towns and country districts, it is chiefly in hospitals that the cutaneous and pulmonary emanations display their power of reproducing the disease. Ten typhus patients, in a ward, discharge by the lungs and skin 600 lbs. of effete matter in 20 days. Now supposing this to be the average time which patients remain in a ward, and that the number mentioned be preserved by the admission of new patients to fill the places of those discharged, for 100 days, the quantity of exhalations in that period will amount to 3000 lbs. With such facts before us, and considering the noxious quality of the exhalations in question, it is plain that nothing short of ventilation, the most efficient, and of cleanliness, the most thorough, can prevent the occurrence of the disease among the nurses and other hospital attendants.

In respect to the principles which compose the exhaled matters from typhus patients, there is reason to believe that, however they may differ in their quantities, they are the same in kind as those from persons in health, namely water, carbonic acid, salts, and animal matter. But whether the proportions of these are relatively the same is problematical. As to the animal matter, we have no means of estimating its quantity. The factor of the breath, and the offensive odour of the sweats, in the graver forms of the disease, indicate that the amount does not fall short, if it do not exceed the quantity discharged in health. In some forms of abnormal excretions

* See Christison on Continued Fever, in Tweedie's Library of Medicine, Phil. edit. pp. 202, 203.

there is a large increase of organic material; and according to Stark albumen exists in the sweat in putrid and some other diseases on the approach of death.* Admitting this to be true in respect to the morbid perspiration and pulmonary excretion in typhus, the cause of the ready diffusion of the disease may be easily explained.

But in tracing the typhus poison to the matters emitted from the lungs and skin, it must not be forgotten that, though the fæces and urine of typhus patients supply nothing essential to its production, they are probably not unfrequently its source, especially when they are discharged involuntarily, and consequently pollute the bedding and clothing of the sick.

In conclusion: from these etiological, let us turn to the hygienic views of our subject.

It is a law of the human economy, which impressively illustrates the wisdom and benevolence of the Creator in respect to the social and domestic relations of men, that the effete materials which are so abundantly and continuously exhaled from their lungs and skin, in health, are never hurtful or offensive to them so long as they live in a space sufficiently ample to allow them to breath a free and pure atmosphere, and their bodies are preserved clean. It is in reference, therefore, to the transpirations of the body that ventilation and personal cleanliness are so clearly demanded by the cardinal laws of hygiene; and as these laws have their foundation in the normal physical relations of man to the external world, the violation of them by crowding individuals into spaces or situations in which the air becomes surcharged with carbonic acid and the other matters of exhalation, is no less productive of disease than is the infraction of any other natural laws on the undisturbed operations of which health depends. It is by the failure to observe these salutary principles that densely populated localities engender the evils of which we have treated.

Though the mode in which we have endeavoured to discuss this subject is more especially interesting to the practical hygienist, yet it brings into view questions relating to organic nature which challenge the notice of the chemical philosopher. We have seen that the quantity of pulmonary and cutaneous excretions from a population of 200,000 adult persons, in one month, is 20,000,000 lbs.

This amount, of course, increases proportionately as greater numbers are made the basis of the calculation; such, for example, as the population of the city of New York, Paris, or London. Now,

* Simon's Animal Chemistry, vol. ii. p. 109.

the principles which constitute the effete matters of transpiration of a city population are derived, for the most part, as they are elsewhere, excepting the water, from animal and vegetable substances, the products of rural districts. These organic substances gathered by human industry, and transported to cities on rivers, railroads, and other highways, and distributed to the inhabitants, serve the purpose of human sustenance. Having answered this end, they are evolved as effete materials from the body, and mostly returned to the country; the gaseous portion finding its way thither by virtue of its diffusive property, and the remaining volatile parts on the wings of the wind. Now, the interests of agriculture in common with those of private and public hygiene, demand that to such a return there should be no hindrance. Allowed to take their natural course, their elements enter into new arrangements, and the resulting compounds, descending to the earth with the dews and rain, and serving as the pabulum of plants, reappear in vegetable forms, fitted as nutriment for man and brute. If this order of nature, so beneficently contrived, and so happily elucidated by Dumas, Boussingault, Liebig, and Fownes, be disturbed, or rather, if but a comparatively small part of the organic matter evolved from the lungs and skin be retained and accumulated in the stagnant air of human habitations, or become attached to garments, bedding, furniture, &c., it may be metamorphosed into an agent destructive to life; and, consequently, so much be withdrawn of the materials designed for the nutriment and growth of plants. In thus adverting to the mutual physical dependencies existing between man and the lowest orders of organic nature, we arrive at the conviction that it rests with the people or rulers of a city to decide the question, whether the matters transpired from their bodies shall be dispersed over agricultural districts, and, in their circle of mutations, be again measurably returned to them as wholesome food, or be retained in their dwellings and transformed into a principle productive of disease.

In perhaps no other mode of investigation than that pursued in the preceding inquiry are we enabled to form a just estimate of the value of personal and domestic cleanliness, and so fully to perceive the importance of making ample provisions in plotting the streets and courts of cities, and in constructing dwellings, workshops, factories, and public edifices, as prisons and almshouses, for securing the advantages of ventilation. If it be ascertained what extent of space, and what degree of perfusion, or change of air in a habitation are requisite for the health of a single individual, it will not be

difficult to calculate what extent of area, and what arrangements for supplying fresh air are necessary to preserve any number of persons or families in a neighbourhood or city from suffering from their own exhalations. It is said by the register general, of England, that "the space allotted to the sleeping rooms of many public institutions in towns is too small." And he remarks that, "it should in no case be less than eight feet cube (= 512 cubic feet) to each person, with proper apertures for the removal of the breath. If the air were removed twice as fast, a room of 500 cubic feet would afford the same advantages with regard to health as a room of 1000 feet; but it is a difficult matter to remove air from a room with double velocity—more difficult and expensive than to make the rooms at least on hand of sufficient extent in the first instance. The mortality in crowded rooms, if carefully investigated, would no doubt be found to be in a certain inverse ratio to the space, a death marking every degree of concentration of the expired atmosphere."

It is demonstrated, in the Parliamentary Reports on the sanitary condition of the lower classes in England, that among the causes of disease in cities, there is none more extensive and active than a deterioration of the air produced by the poor, overcrowded in ill-ventilated dwellings, and by operatives and trades-people, congregated in small and confined apartments. As in such situations, typhus and other forms of disease unquestionably originate, it follows that the means of preventing the evil is to limit the number of inmates in apartments of given dimensions; and to provide dwellings and factories with suitable apertures and sufficient space around them for free ventilation. Such sanitary measures, with attention to personal cleanliness, carried into effect by an efficient police, would put a period to the prevalence of the disorders referred to; and at the same time minister a wholesome rebuke to the mercenary spirit of proprietors and landlords. As there are legislative enactments prohibiting the overcrowding of emigrant ships, why should not legal provision be made to prevent the overcrowding of habitations in cities? For such a law there are precedents. In 1563, Queen Elizabeth commanded that in London, "one dwelling house should not be converted into more;" and, in 1580, she "published a proclamation forbidding any dwellings to be erected on new foundations within three miles of the city gates; and that only one family should inhabit each house."*

JOSEPH M. SMITH, *Chairman.*

* Brewster's Edinburgh Encyclopedia, Article, London.

